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Simulated Alpha Scattering

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May 16, 1973

Simulated Alpha
Scattering

Gerald L. Fuller

alpha Scattering

My approach to the experiment is to use a box of certain dimensions as the Gold atom. This, I'm going to bombard with B.B's as alpha particles. Therefore this is a simulated alpha Scattering experiment. The box is like unto the atom whereas shooting into it you cannot see what happens nor where it happens, but draw on your information taken while observing the effects outside the atom and the box likewise. A screen is used with the atom, and I have used cardboard squares placed in slot around my box to record the direction the particle enters and leaves, in this way it is like the screen. For the alpha particle I'm using a B.B. It is small in comparison to my box as the alpha particle is to the atom.

My purpose for the experiment is to relate my experiment with actual alpha Scattering and to come up with the same conclusions.

Calculating the size of Gold atom using B.B in Relation with the Alpha Particle

According to Henry Semat in his book "Introduction to Atomic and Nuclear Physics" the mass of an alpha Particle is $M = 6.62 \times 10^{-24} g$. This is found on Page 98.

The velocities of the alpha Particles are in the order of magnitude of 10^9 m/sec.

In the Book "Nuclear Physics and the Fundamental Particles", written by Harry H. Heckman and Paul W. Starring, tells that the size of an atom my be calculated by use of Avogadro's number N_A, the atomic weight A, and the material density ρ,

$$A / \rho = \propto cm^3$$

in this volume there are N_A atoms. Therefore the volume of one atom is,

$$A / N_A \rho$$

$$V = \frac{197 g}{(6.02 \times 10^{23})(19.3 \; g/cm^3)} =$$

$$= \frac{1.97 \times 10^2}{1.16 \times 10^{25}}$$

$V = 1.7 \times 10^{-23} cm^3$ Size of Gold atom

I have also found a formula to find the volume of a Helium Nucleus.

$V = 4/3 \pi R_0^3 A$

$R_0 = 1.2 \times 10^{-13}$ cm

A = number of nucleons which it contains

Therefore

$V = 4/3 \ (3.14)(1.2 \times 10^{-13})^3 (4)$

$V = 4/3 (3.14)(1.728 \times 10^{-39})(4)$

$V = \frac{(16)(3.14)(1.728 \times 10^{-39})}{3}$

$V = (50.28)(1.728 \times 10^{-39})$

$V = 8.68 \times 10^{-38}$ cm³ Size of Alpha Particle

calculation of the volume of B.A

$r = .22$ cm

$V = 4/3 \pi r^3$

$V = 4/3 (3.14)(.22)^3$

$V = \frac{(12.56)(.0106)}{3}$

$V = \frac{.133}{3} = .044$ cm³

$$\frac{\text{Volume of ALPHA P.}}{\text{Volume of Gold Atom}} = \frac{\text{Volume of B.B}}{\text{Volume of Box}}$$

$$\frac{8.68 \times 10^{-38}\ cm^3}{1.7 \times 10^{-23}\ cm^3} = \frac{4.4 \times 10^{-2}\ cm^3}{x}$$

$$x\,(8.68 \times 10^{-38}\ cm^3) = 7.48 \times 10^{-26}\ cm^3$$

$$x = 8.64 \times 10^{11}\ cm^3$$

$$s^3 = 8.64 \times 10^{11}\ cm^3$$

$$s^3 = .864 \times 10^{12}\ cm^3$$

$$s = .205 \times 10^4\ cm$$

This would be a box 20 yds long by 20 yds wide by 20 yds deep.

This is a rediculous size, therefore I adopted a size of my own, a more practical size and drew my conclusion from there.

The size I chose was 30 cm X 30 cm X 30 cm approximately. After have my 12" X 12" top and bottom squared it come out 27 cm X 27 cm, therefore I decided to make my box (27 X 27 X 27) cm³.

Construction of Box:

I used aluminum angles for my corner support. They were light and yet strong and much easier to work with. This came in an 8 ft. piece, so I had to cut it and file each of the ends. After cutting my four supports, I had some aluminum angle left. I decided to use what I had left for slats to hold the construction paper. I measured what I had left and divided it into eight pieces. To make it work well I marked each piece in the center. This was to make it uniform top and bottom.

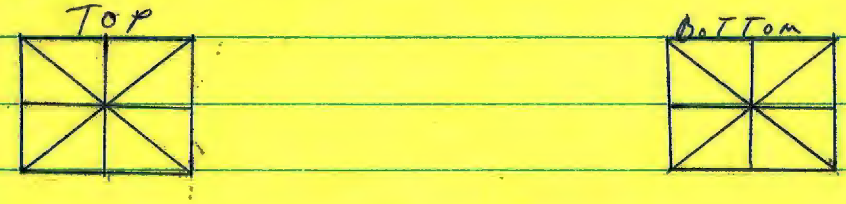
The top and bottom were two pieces of pine 12"X12". I took them to the shop and had them squared. This left them 27cm X 27cm.

To these I drew two lines intersecting each other and at the center of the top and bottom.

This was used to place the center of each piece (slats) of aluminum in the center of the top and bottom of the box.

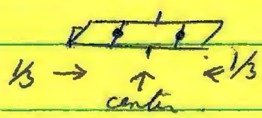
I found a Steel rod in my father's workshed and decided to use this for my nucleus. I cut it approximately 31 cm long. It was 9 mm in diameter or 3/8" diameter, so I used a 7/16" bit and drilled a hole in the top and bottom

To make sure I had it centered I draw two diagonals on each.



Putting the box together I used my corner pieces first. I drilled holes in the corner pieces alternating them, so the screws would not hit. I used small wood screws to hold the box together, 2 top and bottom on each corner piece.

Nexted I puts my slat pieces in. I measured each slat; divided it into 3 parts and measured 1/3 from each end



This is where I drilled the holes for the wood screws.

Now I put this (slat) on the box. The center of the slat to the middle of each side.

Having the holes already drilled in the top and bottom, my box was completed on putting my rod through the center.

Experiment:

I bought four different colors of construction paper. Each one was to be for a different experiment. They were #1 GREEN, #2 Orange, # Red, # 4 BLACK.

I measured the distance between my slats and also between my corner supports. I made my cardboard pieces a fraction smaller. 23.4 cm X 25.8 cm. I cut this out on the paper cutter in lab.

During the experiment I placed cardboard and Styrofoam around it to capture and stop the B.B's from scattering all over the room.

Experiment # 1

Green

DATA.			sides			
SHOT NUMBER	TOP	1	2	3	4	BOT
1		x		x		
2		x		x		
3		x		x		
4		x		x		
5		x			x	
6		x				x
7	x	x				
8		x				x
9		x		x		
10		x		x		

Experiment # 2

Orange

DATA		Sides				
SHOT NUMBER	Top	1	2	3	4	bot
1		x		x		
2		x	x			
3		x		x		
4		x		x		
5		x		x		
6		x		x		
7		x		x		
8		x		x		
9	x	x				
10		x		x		
11		x	x			
12		x		x		
13		x				x
14	x	x				
15		x				x

Experiment # 3

DATA		Red Sides				
SHOT NUMBER	TOP	1	2	3	4	Bot
1		x			x	
2		x		x		
3	x	x				
4		x		x		
5		x	x			

Having enough data and my time running out and did not go on with experiment # 4.

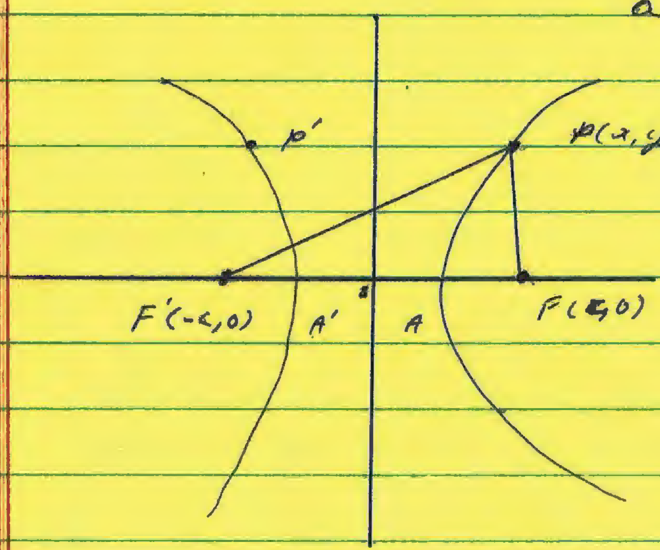
Proving Hyperbolic Path.

I'm going to used the Data from experiment #1 to show that the B.B traveled in a hyperbola path.

First I will state that and alpha Particle in an alpha Scattering experiment travels in the path of a hyperbola. Richard T. Weidner and Robert L. Sells book elementary modern Physics Second Edition page 224.

The nexted page consists of hyperbola Proof, and Some formullas used.

Definition of Hyperbola - The locus of points the difference of whose distances from two fixed points is constant is a hyperbola.



$PF' - PF = 2a$

$\sqrt{(x+c)^2+y^2} - \sqrt{(x-c)^2+y^2} = 2a$

$\sqrt{(x+c)^2+y^2} = 2a + \sqrt{(x-c)^2+y^2}$

$x^2 + 2xc + y^2 = x^2 - 2cx + y^2 + 4a\sqrt{(x-c)^2+y^2} + 4a^2$

$cx - a^2 = a\sqrt{(x-c)^2 y^2}$

$c^2x^2 - 2cxa^2 + a^4 = a^2x^2 - 2acx + a^2c^2 + a^2y^2$

$x^2(c^2 - a^2) - a^2y^2 = a^2(c^2 - a^2)$ let $c^2 - a^2 = b^2$

then

$x^2 b^2 - a^2y^2 = a^2b^2$

or

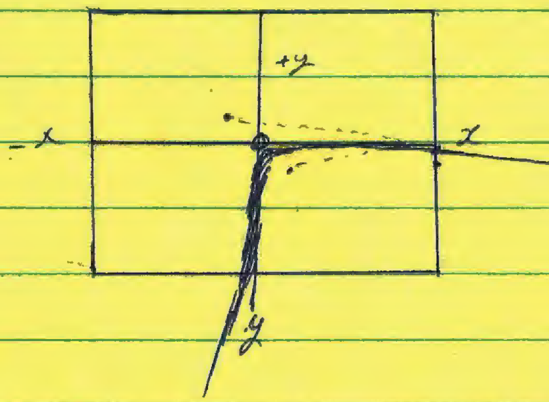
$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$$

I cannot use the rod as my origin as they could with the gold nucleus. The reason being, there isn't any electromagnetic replusive force. Therefore it is actually more like simulated neutron scattering.

Experiment # 1

Slot # 5 went through the front side (1) and the right side (4)

I have to use the center of the rod as the origin.



Since my hyperbola is so close to being a rectangular hyperbola that I used $e = \sqrt{2}$

$f = ea$

$A = .4.5$ cm

$e = 1.414$

$f = (.4.5 \text{ cm})(1.414)$

$F = .636$ cm

Point $(.25, -13.2)$

Focus $(.636, -.636)$

$D_1 = \sqrt{(.25 - .636)^2 + (-13.2 + .636)^2}$

$D_1 = \sqrt{158.0274}$

$D_1 = 12.6$

Point $(.25, -13.2)$ and $(-.636, .636)$

$D_2 = \sqrt{(.25 + .636)^2 + (-13.2 - .636)^2}$

$D_2 = \sqrt{192.1904}$

$D_2 = 13.8$

$D_2 - D_1 = 13.8 - 12.6 = 1.2$

which is suppose To be equal To $2A$

$2A = 2(.45) = .9$

$$\begin{array}{r} 1.2 \\ -.9 \\ \hline .3 \end{array}$$

which is 33⅓% error

I account for this error in assuming I had a rectangular hyperbola. I should have rotated my axis.
Also I believe I could have made a error in my measurement.

Conclusion

This experiment purpose was to come to the same conclusions as the actual alpha Scattering experiment.

There was a pattern and scattering. Also a very large percentage of the shots missed the bar which is logical because the size of the nucleus is quite small compared to the size of the atom.

Although my calculation on the hyperbola were off by 33%, I believe it was an error on my part, not the experiment. I wished I'd had more time.

I have learned so much more from this experiment than I have in actual class work. I would attribute this to finding something I'm interested in and that I work as an individual.

I conclude that the experiment was a success.